# Jet Observables New and Old

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# Jet structure in the RHIC and LHC era

- From General Meeting:
  - Jet measurements in heavy-ion collisions have evolved in the last year
    - Truly the era of jet structure
    - HEP inspired observables
  - Which observables (new and old) should the next generation jet (and ϒ!) detector focus on?
    - $\sqrt{S_{NN}}$ dependence → 200 GeV vs 2.76, 5 TeV
    - Focus on differential measures at 200 GeV
- What are we going to show in the first QM after sPHENIX turns on?
  - Statistics?
  - Detector calibration?
  - Comparison to existing LHC/RHIC results?
  - State-of-the-art?
- What should we show for QM 2017?

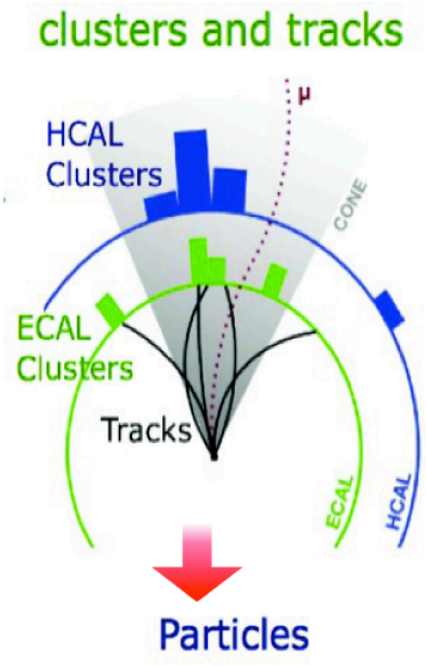
# Caveats

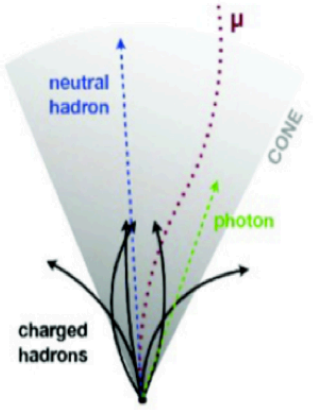
- I have probably overlooked some observables/results, it is not intentional
- I am prepared to be convinced other “day 1” analyses are better for our program
  - This is a brainstorm of what we have and could do

# Jet structure in the RHIC and LHC era

- Observables
  - Jet grooming
  - Jet fragmentation (Moments?)
  - Jet mass
  - Subjets
  - γ-jet
  - Jet shape
  - Jet girth
  - $p_T$D, LeSub
  - Spectra (jet and high $p_T$ hadron)
  - Dihadron/γ-hadron Correlations
  - $A_J$, Neighboring jets, missing $p_T$, Jet-h, h-Jet and others

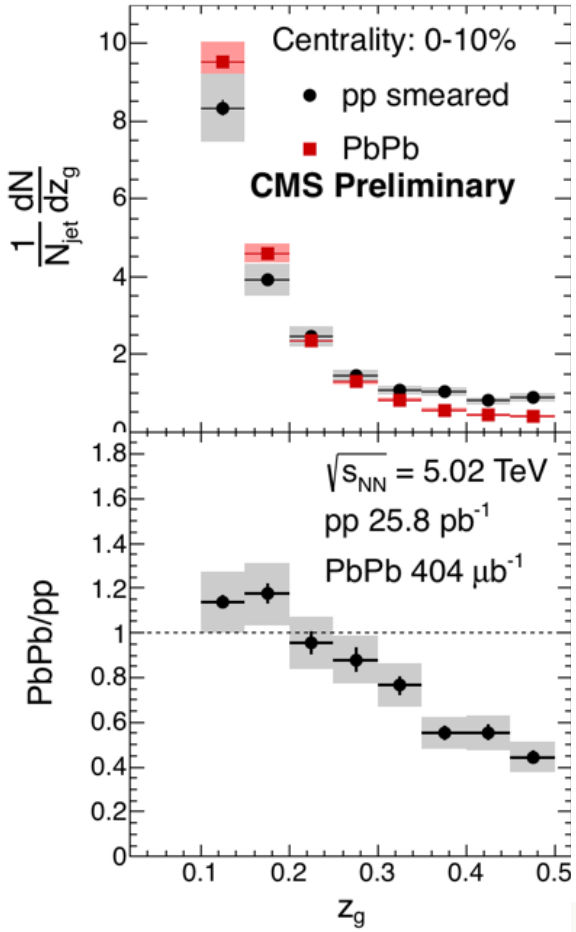
Algorithms



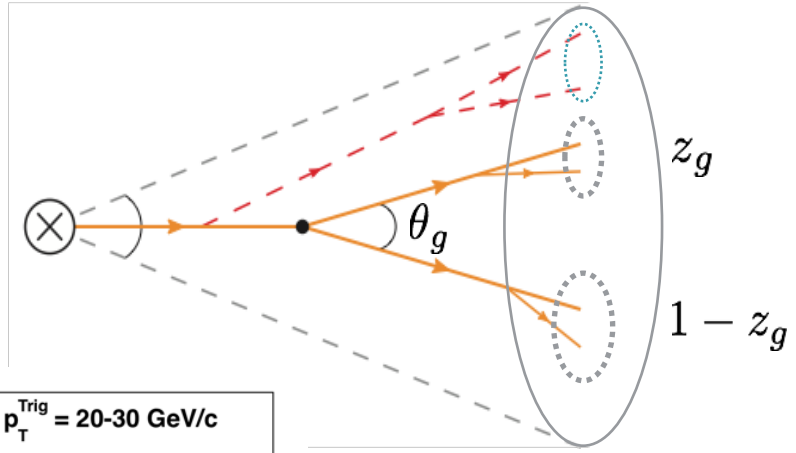



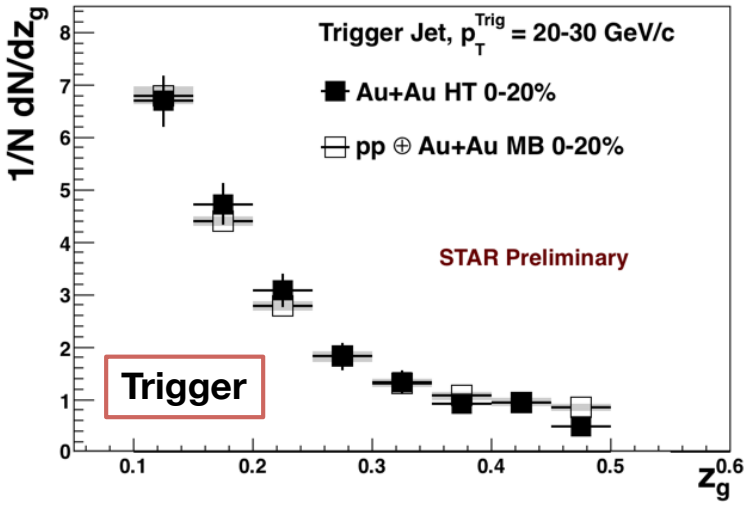
# Jet Grooming ($z_g$)

- Observable: Momentum fraction carried by the subleading branch of first splitting
  - Independent of flavor (q/g fraction irrelevant)
  - Measured at LHC (CMS) and RHIC




$$z_g = \frac{\min(p_{T,1}, p_{T,2})}{p_{T,1} + p_{T,2}}$$



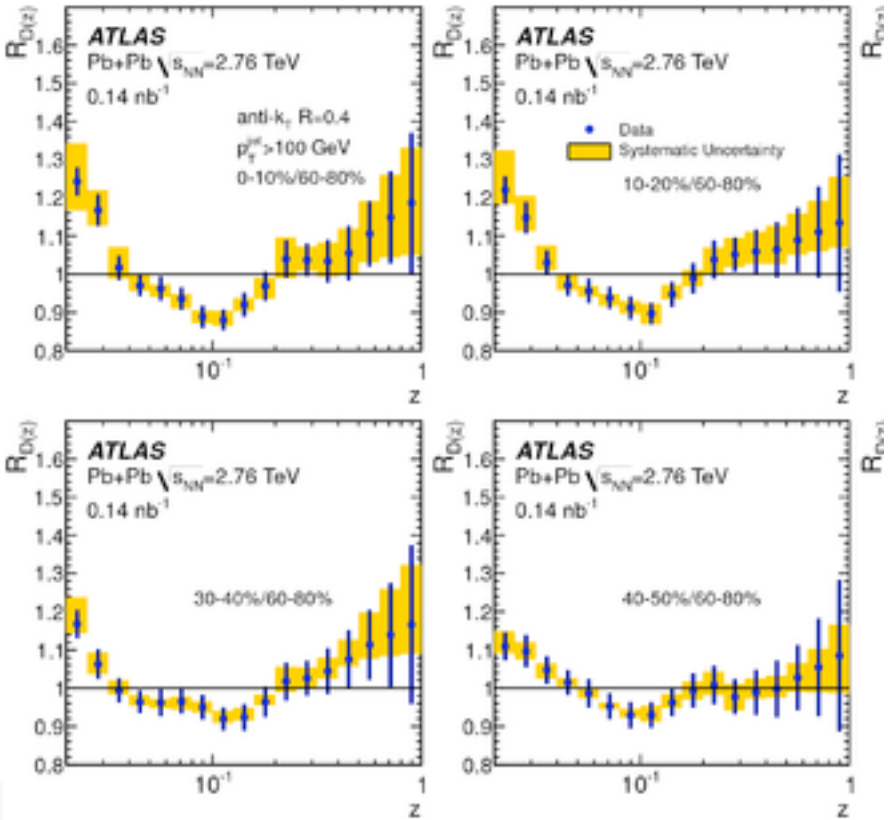



# Jet Fragmentation

- Fragmentation functions → modification of parton showers
  - transverse momentum and longitudinal momentum fraction
- Measured at LHC (Atlas,CMS)
- Not Measured at RHIC

$$z = \frac{p_{\parallel}^{track}}{p_{jet}} \qquad D(z) = \frac{1}{N_{jet}} \frac{dN_{ch}}{dz}$$

$$\zeta = \ln \frac{1}{z}$$



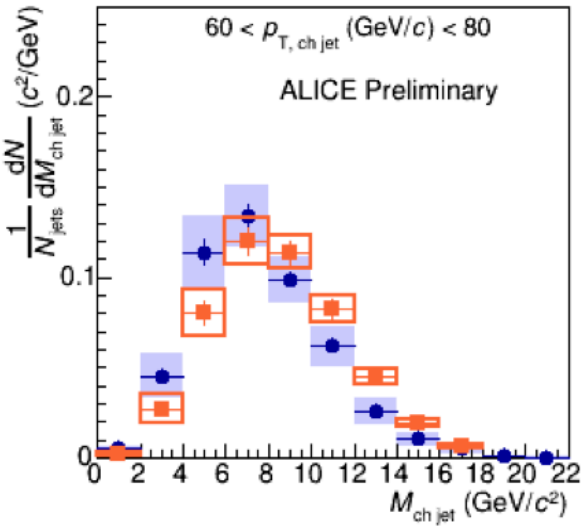
# Jet Mass

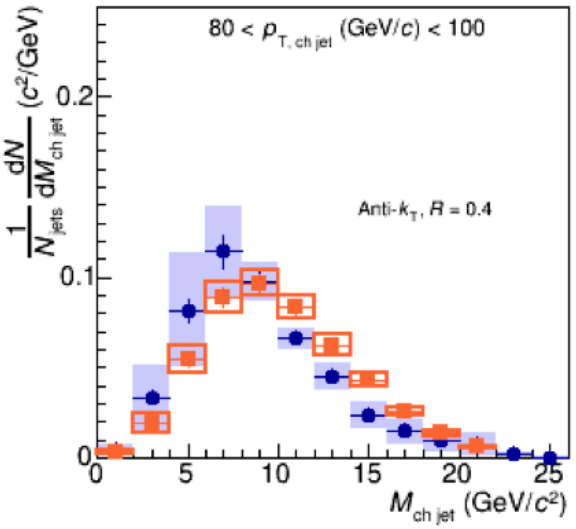
- Measure "mass" of jet from constituents
  - Allows a "second" axis of comparison
  - Background method?

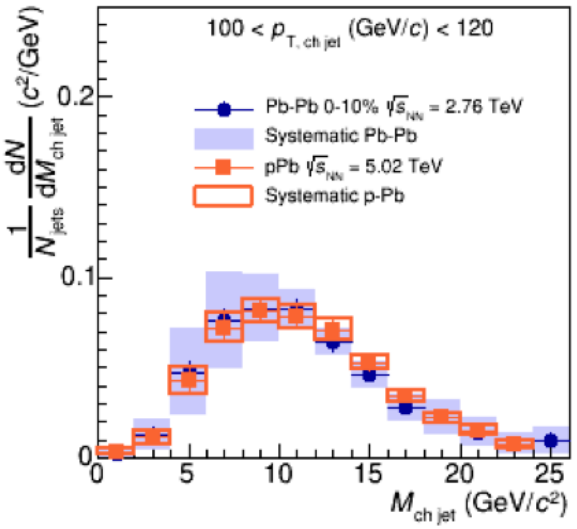
$$M = \sqrt{p^2 - p_T^2 - p_z^2}$$

$$p = \sum_{i=1}^{n} p_{Ti} \cosh \eta_i$$

$$p_z = \sum_{i=1}^{n} p_{Ti} \sinh \eta_i$$

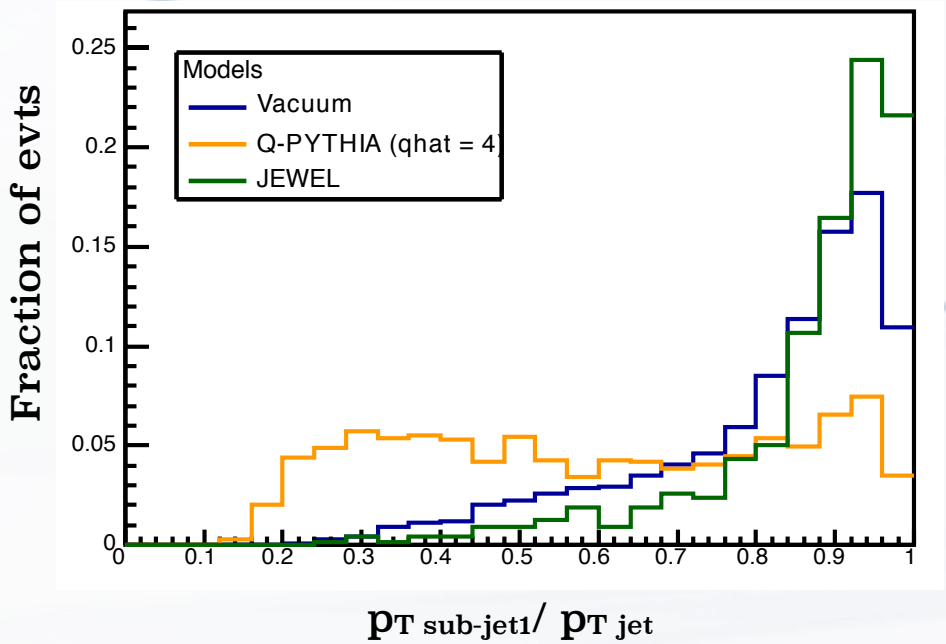


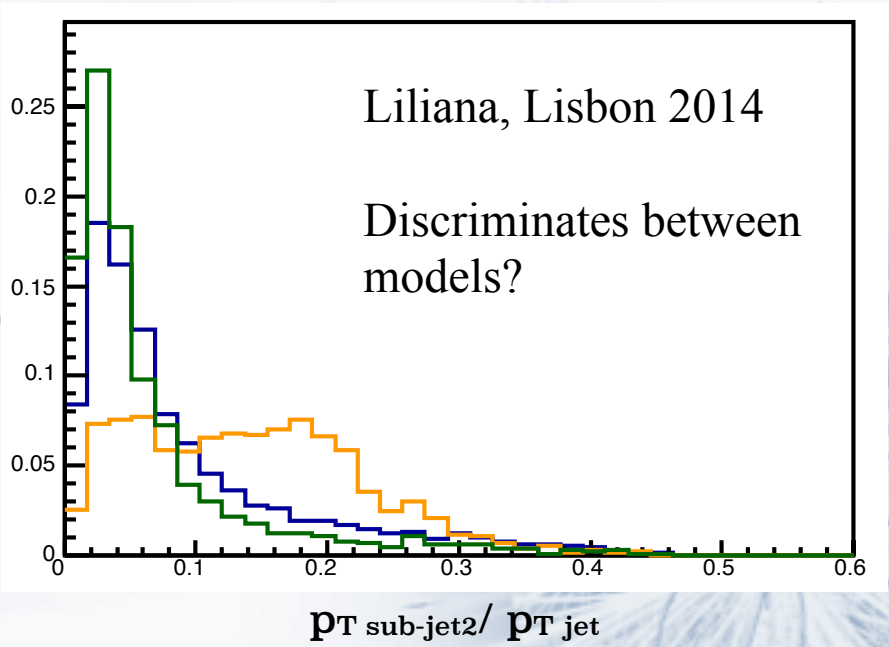



# Subjets

- Subjets <-> Splitting
- Less effected by background
- I'm missing some details here, but this could be an interesting pursuit

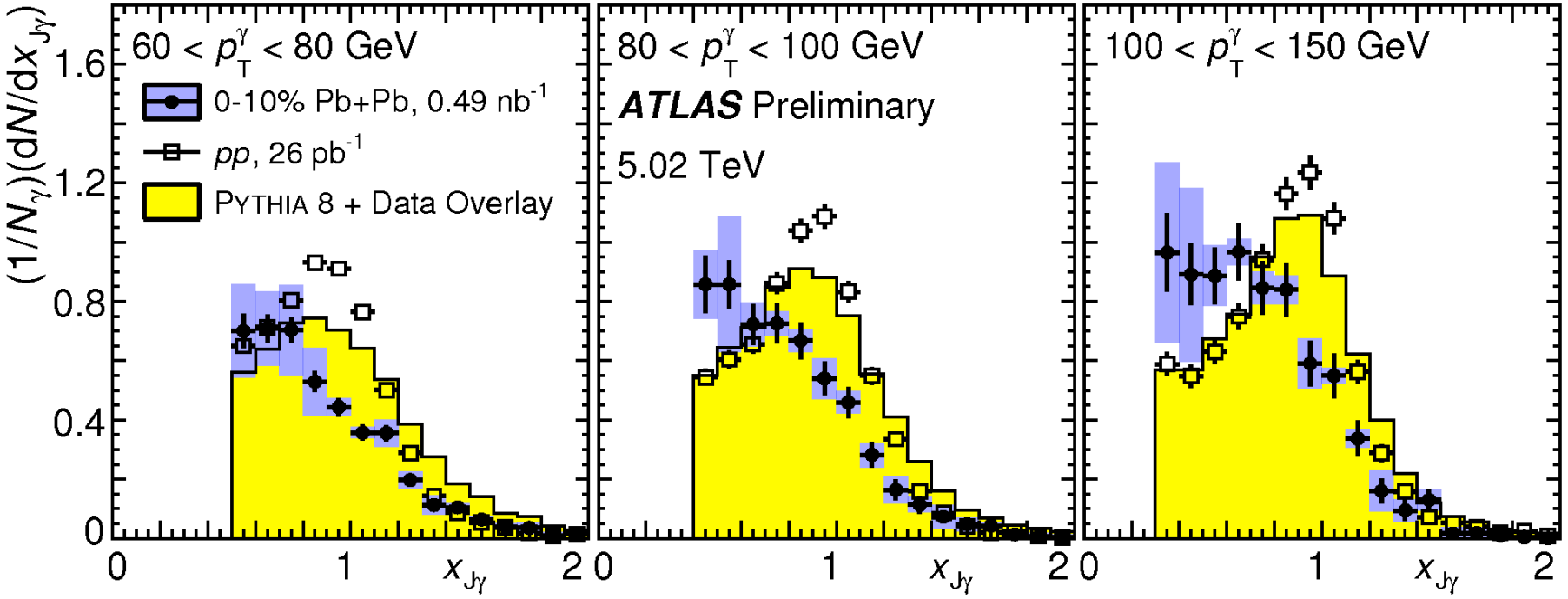


# γ-Jet

- Golden channel! (A key series of observables)
- Measured at LHC (Atlas, CMS)
- Not Measured at RHIC (γ-hadron!)
- Calo only measure?!? ($X_{J\gamma}$)

$$X_{J\gamma} = \frac{p_{T,jet}}{p_{T,\gamma}}$$

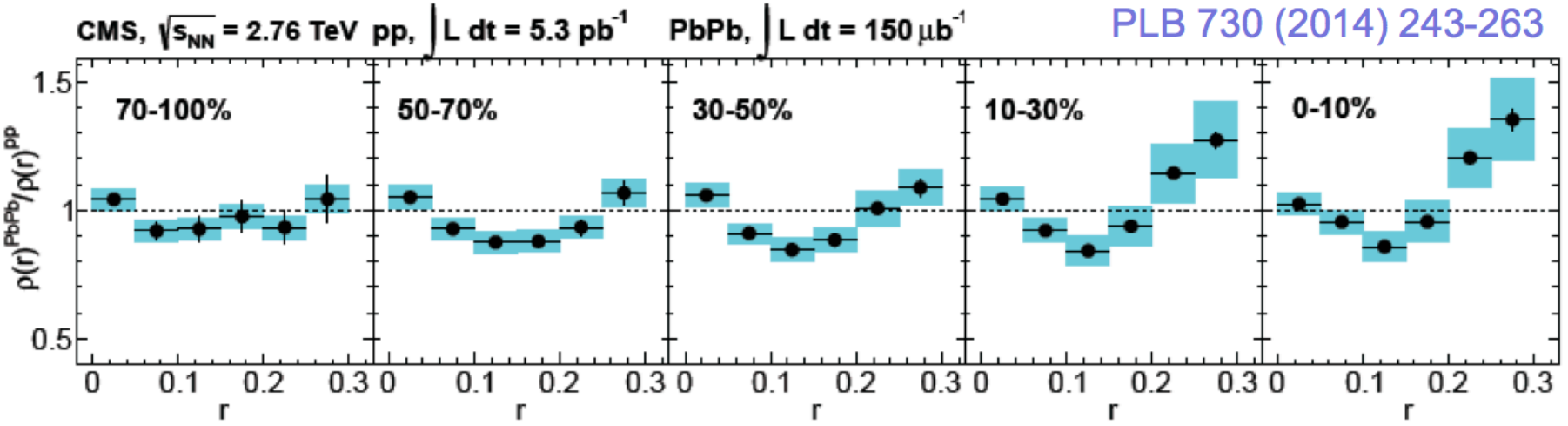


# Jet Shape


- Sum Transverse momentum
- Measured at LHC (CMS)
- Not Measured at RHIC

$$\rho(r) = \frac{1}{\delta r}\frac{1}{N_{jet}}\sum_{jets}\frac{\sum_{tracks\in[r_a,r_b)} p_{T,track}}{p_{T,jet}}$$

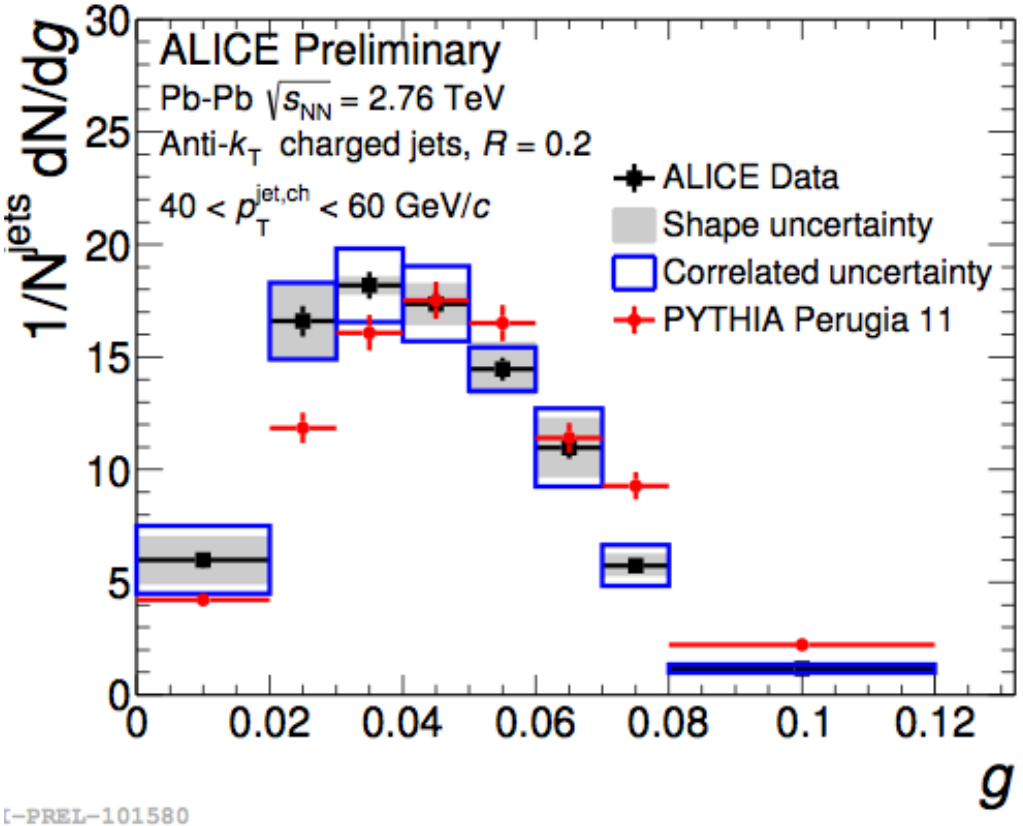
- We want to measure the modification of the jet in both constituent momentum and position from the jet axis!
- γ-jet shape? (See SCET group!)



# Jet Girth

- g is $p_T$ weighted width of the jet
  - broadening → enhanced g
  - collimation → reduced g
- Measured at LHC (ALICE)
- Not Measured at RHIC
- Low enough $p_T$ for overlap

$$g = \frac{\sum_{tracks} p_{T,track} r}{p_{T,jet}}$$

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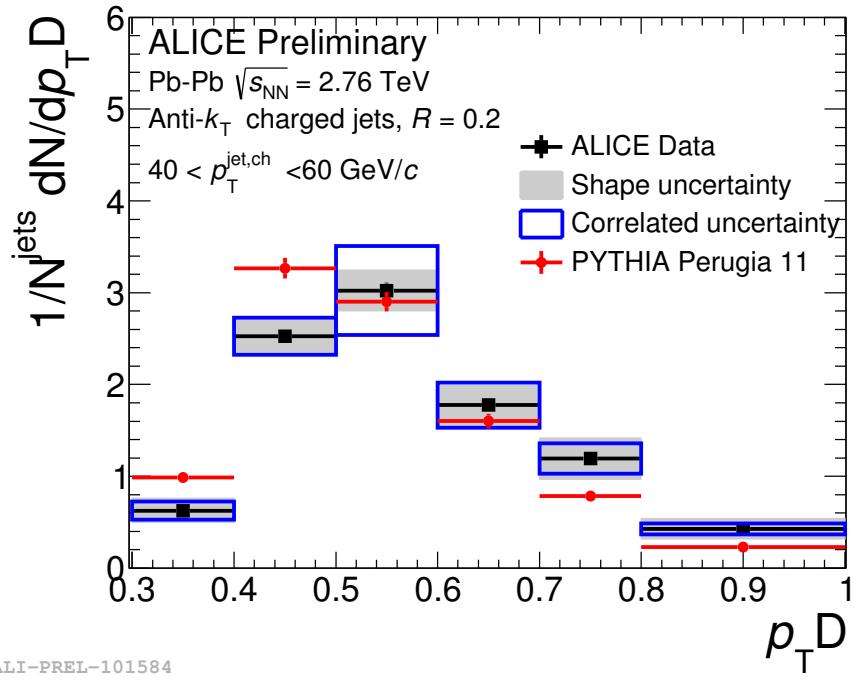
# $p_T D$

- $p_T D$ measures $p_T$ dispersion:
- Less constituents → more democratic splitting → reduced $p_T D$
- Measured at LHC (ALICE)
- Not Measured at RHIC
- Low enough $p_T$ for overlap
- Differential?

$$p_T D = \frac{\sqrt{\sum_{tracks} p_{T,track}}}{p_{T,jet}}$$

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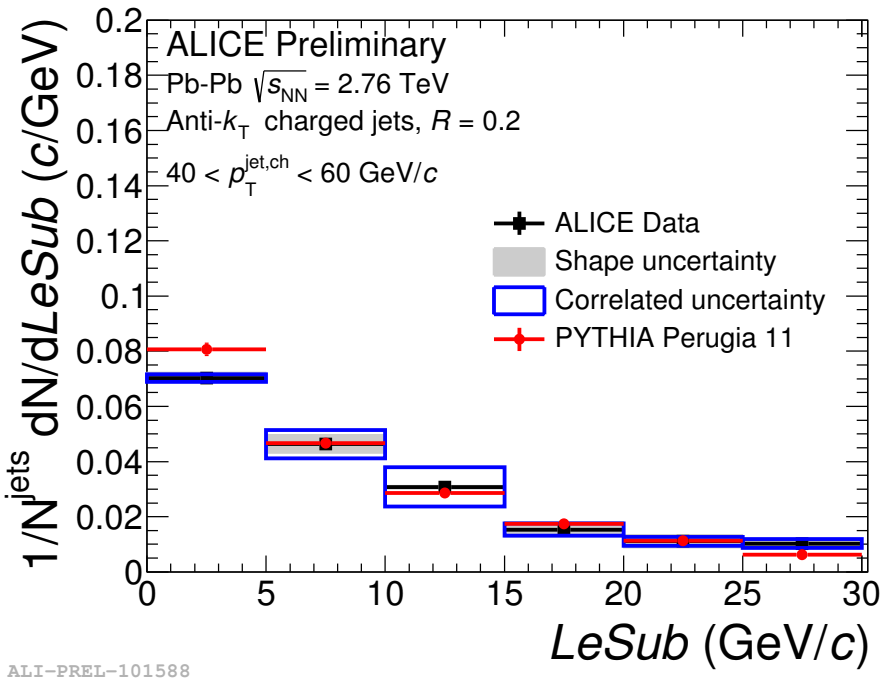
# LeSub

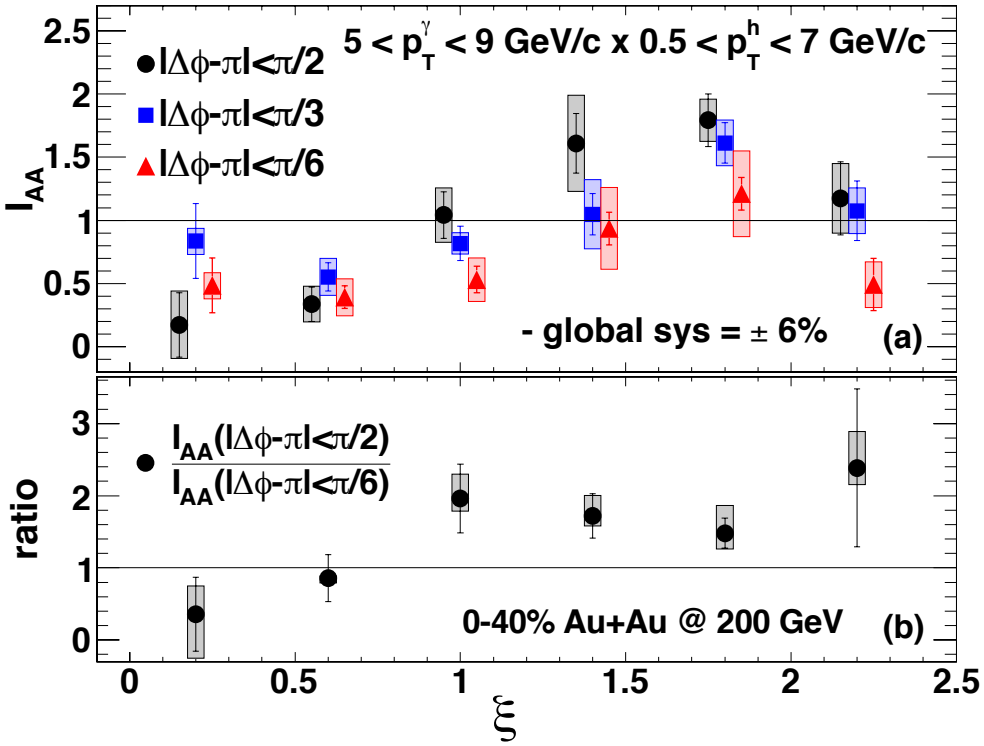
- LeSub characterizes hardest splitting
  - Insensitive against background
- Measured at LHC (ALICE)
- Not Measured at RHIC
- Low enough $p_T$ for overlap
- Simple → Differential?

$$LeSub = p_{T,track}^{Lead} - p_{T,track}^{Sublead}$$



# Spectra/dihadron/γ-hadron


- "Traditional measures"
  - Good benchmark to connect with prior data
  - Community expectations → We all "understand" $R_{AA}$
  - Differential?
- In the case of spectra-type observables we may want to delay to "day 2" as ratio measures require less calibration



# QM2017

- My thoughts were:
  - Jet Fragmentation – Showcases both calorimeter and tracking performance – differential
  - γ-jet correlations – Photons have been highly advertised, also the community views this as a "golden" channel
    - Calo only?
- Something basic → high pT spectra?
- Something new?